EXCHANGE ANISOTROPY OF MACROSPINS IN SUPERFERRIMAGNETIC STRUCTURE

LABORATORY : Institut Lumière Matière

LEVEL : M2
TEAM(S) : ENERGIE

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KEYWORD(S) : Nanoparticules / Magnétisme

SCIENTIFIC CONTEXT :

Single-domain magnetic nanoparticles (NPs) exhibit unique magnetic properties that differ markedly from those of bulk materials. In the simplest model of a single-domain ferromagnet (FM), all spins align parallel, allowing the particle to be treated as a macrospin [Stoner, 1948]. In practice, surface atoms often differ from the core in spin moment, anisotropy, or orientation. Due to their large surface-to-volume ratio, interfacial couplings offer a powerful way to control magnetization. Many fundamental questions thus remain open, while these tunable properties also hold strong potential for technological applications such as high-density magnetic data storage.

This project focuses on the magnetic behavior of NPs integrated into a superferrimagnetic (SFiM) heterostructure. In contrast to conventional ferrimagnets (FiMs), where two spin sublattices are antiparallel with unequal moments, a SFiM combines two FM phases of different magnetizations, coupled antiparallel at their interface. First proposed by Akdogan et al. [2014] to enhance the demagnetization resistance of permanent magnets, this concept has so far been studied only in bulk or micrometer-thick films [Le Roy, 2014], composed of multidomain FM grains and a soft, exchange-coupled intergranular phase.

MISSIONS :

The internship aims to explore the superferrimagnetic (SFiM) concept in systems of single-domain nanograins, a regime never investigated before. Due to the increased effective magnetic volume from interfacial coupling and the reduced net magnetization from antiferromagnetic (AFM) interactions, both higher thermal stability and larger reversal fields are expected. The objective is to experimentally quantify these effects in Co/Gd heterostructures. The samples will be produced using the PLYRA facilities (ILM-Tech, Lyon). Co nanoparticles will be synthesized by Low Energy Cluster Beam Deposition (LECBD) under ultra-high vacuum ($\approx 10^{-10}$ mbar), with mass selection ensuring a narrow size distribution (1–8 nm). Gd layers will be grown by electron-beam evaporation to form Co/Gd assemblies. Magnetic characterization—focusing on macrospin reversal dynamics and thermal stability—will be carried out using a Superconducting Quantum Interference Device (SQUID) magnetometer.

OUTLOOKS :

PhD continuation possible, with secured funding already available.

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published on 03/11/2025